

1 We claim:

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3 1) A diffractive structure which applies a specified complex-valued spectral filtering  
4 function to an input optical field and which emits a filtered version of the input field in an  
5 output direction, said diffractive structure comprising:

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7 a plurality of spatially distinct subgratings,

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9 each subgrating possessing a periodic array of diffraction elements.

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11 2) The structure recited in claim 1 wherein each of said subgratings has an amplitude,  
12 spatial phase shift, and spatial period ( $A_i$ ,  $x_i$ , and  $\Lambda_i$ ) and a transmissive optical phase  
13 shift ( $\phi_i$ ) introduced by a variation in substrate thickness or superimposed phase mask  
14 and wherein the amplitude and phase parameters of each of said subgratings is defined  
15 in terms of

16 
$$a_i = \beta d \int_{m/(\beta\Lambda)-1/(2\beta d)}^{m/(\beta\Lambda)+1/(2\beta d)} \frac{T(v)}{F(v)} \exp(-j\pi(v\beta - m/\Lambda)(x_i^a + x_i^b)) dv$$

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18 in the sense that  $A_i$  is set by the amplitude of  $a_i$  and the phase of  $a_i$  sets a combination  
19 of  $x_i$  and  $\phi_i$ .

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21 3) An optical structure which applies a specified complex-valued spectral filtering  
22 function to the input optical field and which emits a filtered version of the input field in an

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1 output direction said filtered output having a temporal structure essentially matching a  
2 reference optical waveform, said structure comprising,

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4 a plurality of subgratings combining to form a segmented grating with a particular  
5 transfer function determined by said reference optical waveform.

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7 4) An optical structure which applies a specified complex-valued spectral filtering  
8 function to the input optical field and which emits a filtered version of the input field in an  
9 output direction said filtered output having a temporal structure essentially matching the  
10 cross correlation of the input field with a reference optical waveform, said structure  
11 comprising, a plurality of subgratings combining to form a segmented grating with a  
12 particular transfer function determined by said reference optical waveform.

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15 5) An optical system for optical code division multiple access (OCDMA) for multiplexing  
16 and demultiplexing a plurality of optical signals in accordance with a set of reference  
17 optical waveforms, each reference optical waveform comprising a sequence of time  
18 slices, said system comprising grating devices each comprising

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20 one or more segmented gratings,

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22 each said segmented grating having a spectral transfer function determined by its

23 constitutive subgrating parameters  $A_i$ ,  $\phi_i$ ,  $x_i$ , and  $\Lambda_i$  that matches a particular reference

- 1 optical waveform,
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- 3 multiplexing multiple optical data streams by directing each onto to a specific segmented
- 4 grating along its operative input direction thereby producing an output beam encoded
- 5 according to the reference optical waveform encoded in said specific segmented
- 6 grating,
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- 8 demultiplexing a time-code multiplexed optical data stream from a OCDMA channel by
- 9 directing said OCDMA channel along the operative input direction of a segmented
- 10 grating encoded so as to direct said time-code multiplexed optical data stream in a time-
- 11 code specific output direction.
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- 13 6) The structure recited in claim 1 wherein the spatial placement of the various
- 14 subgratings is employed to control the spectral transfer function of the structure.
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- 16 7) The structure recited in claim 1 wherein the amplitude of the various subgratings
- 17 control the spectral transfer function.
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- 19 8) The structure recited in claim 1 wherein the optical thickness of the various
- 20 subgratings comprising the segmented grating is controlled by variation of substrate
- 21 thickness, addition of segmented phase masks, or other means known in the art to
- 22 control the spectral transfer function of the segmented grating.
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- 24 9) The structure recited in claim 1 wherein the addition of active devices as known in
- 25 the art to dynamically change subgrating optical thickness, phase mask optical

1 thickness, optical transmission, or placement allow for the dynamical reprogramming of  
2 the subgrating parameters and thus the spectral transfer function of the segmented  
3 grating.

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5 10) The structure recited in claim 1 wherein the subgratings are transmissive gratings.

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7 11) The structure recited in claim 1 wherein the subgratings are reflective gratings.

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9 12) The structure recited in claim 1 wherein the subgratings comprise a planar surface.

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11 13) The structure recited in claim 1 wherein the subgratings comprise a non-planar  
12 surface shaped so as to map the input spatial wavefront onto a desired output spatial  
13 wavefront.

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15 14) A method of applying a specified complex-valued spectral filtering function to light in  
16 an input optical field by passing said light through a structure which combines plurality of  
17 spatially distinct subgratings, each subgrating possessing a periodic array of diffractive  
18 elements, said subgratings combining to form a segmented grating with a particular  
19 spectral transfer function.

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21 15) A method of applying a specified temporal waveform onto an input optical field by  
22 passing said light through a structure which combines a plurality of spatially distinct  
23 subgratings, each subgrating possessing a periodic array of diffractive elements, said  
24 subgratings combining to form a segmented grating programmed to produce said  
25 specified temporal waveform.

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